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POPULATION DYNAMICS OF *TYLODELPHYS DESTRUCTOR* AND *DIPLOSTOMUM MORDAX* (DIGENEA: DIPLOSTOMIDAE) CO-OCCURRING IN THE BRAIN OF PATAGONIAN SILVERSIDES FROM LAKE PELLEGRINI, PATAGONIA, ARGENTINA

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ABSTRACT: Studies on infection patterns of diplostomid parasites in commercially exploited fishes have not been done in Patagonia (Argentina). The aim of this work was to study the population dynamics of two diplostomid species in the brain of Patagonian silversides (*Odontesthes hatchery*), the interaction between them, and effect on health and physical condition of the hosts. *Tylodelphys destructor* and *Diplostomum mordax* metacercariae in the brain of Patagonian silversides in Lake Pellegrini were studied between January 1991 and February 1992. *Tylodelphys destructor* parasitized all silversides examined; prevalence of *D. mordax* varied between 7% and 100%. Mean intensity for *T. destructor* was 35–140 and for *D. mordax* was 3–49. Highest mean intensities of *T. destructor* coincided with the lowest mean intensities of *D. mordax*. Recruitment seems to occur from July–November for *T. destructor* and from April–June for *D. mordax*, revealing a temporal segregation with inverse patterns of infection and recruitment. *Tylodelphys destructor* has higher intensities in the brain of the older fish, whereas *D. mordax* did not, suggesting another type of segregation. There were no evidences of gross pathology. No covariation between abundance of larvae and condition factor, gonadosomatic index, and gut fullness was detected.

Key words: Diplostomiasis, *Tylodelphys destructor*, *Diplostomum mordax*, silversides, *Odontesthes hatchery*, Patagonia.

INTRODUCTION

Ostrowski de Núñez (1977) studied the life cycle of *Diplostomum mordax* (Szidat and Nani, 1951), identifying planorbid snails (*Biomphalaria peregrina*), silversides (*Odontesthes bonariensis*), and cormorants (*Phalacrocorax olivaceus*) as first, second, and definitive hosts, respectively. The second intermediate host of *Tylodelphys destructor* (Szidat and Nani, 1951) is the Patagonian silverside (*Odontesthes hatchery*), the others hosts remain unknown.

Heckmann (1992) found inflammation in fish neural tissues caused by *D. mordax* in Lake Titicaca (Peru). Siegmund et al. (1997) did not detect inflammation in the brains of Chilean silversides (*Basilichthys australis*) parasitized by diplostomids. In Argentinean reservoirs, Fuster de Plaza and Boschi (1957) found starved *O. bonariensis* with vertebral deformities, and related these characteristics to the abundance of *D. mordax* metacercariae in the brain. In Patagonia (Argentina), Szidat and

Nani (1951) described the metacercariae of *T. destructor* and *D. mordax*. They indicated these species were responsible for starvation in Patagonian silversides from Pellegrini Lake, considering thin intestinal walls a sign of starvation and presence of snail shells in the intestine as abnormal feeding and altered alimentary capability.

In Chile, Torres et al. (1996) studied the seasonal dynamics of *T. destructor* and *D. mordax* in Chilean silversides from Lake Riñihue. These authors did not find any relation between parasites and fish health, probably due to low intensities. Studies on the co-occurrence of diplostomid larvae of different species in eyes showed that high intensities of the species did not occur simultaneously, suggesting negative interaction between parasite species (Kennedy and Burrough, 1977; Burrough, 1978; Kennedy, 2001). Diplostomid larvae in the brain of fish have been considered causative agents of vertebral and cranial deformities (Fuster de Plaza and Boschi, 1957; Sandland and Goater, 2001) and starvation

TABLE 1. Sample dates, water temperature (C), number of Patagonian silversides examined, prevalence, and mean intensity of *Tyloodelphys destructor* and *Diplostomum mordax*.

Date	Water temperature	Number of silversides examined	<i>T. destructor</i> prevalence	Mean intensity	SD	<i>D. mordax</i> prevalence	Mean intensity	SD
Jan-91	23.7	15	100%	95	51.2	7%	5	1.3
Apr-91	20	15	100%	83	37.8	33%	6	5.9
Jun-91	12.3	15	100%	35	16.0	100%	49	43.4
Jul-91	12.5	15	100%	92	32.2	73%	2	1.3
Aug-91	10.3	15	100%	74	43.8	87%	10	11.7
Nov-91	18.7	15	100%	129	72.8	20%	5	2.5
Dec-91	21.3	15	100%	101	48.9	47%	3	2.7
Jan-92	23	15	100%	140	41.1	53%	3	1.9
Feb-92	24.5	15	100%	81	42.7	100%	24	21.5

(Szidat and Nani, 1951). The aim of this work was to study the population dynamics of *T. destructor* and *D. mordax* in the brain of Patagonian silversides, the interaction between these parasites, and effect on health and physical condition of commercially exploited fish in Lake Pellegrini, Argentina.

MATERIALS AND METHODS

Lake Pellegrini is a shallow mesohaline and eutrophic artificial lake on the Patagonian Plateau in Río Negro Province, 25 km from the confluence of Rivers Limay and Neuquén (38°40'S, 68°00'W). It has a surface area of 400 km², a maximum depth of 18 m, and a mean depth of 9.4 m.

Patagonian silverside is a native species and is commercially exploited in Lake Pellegrini. Adults are omnivorous, feeding on planktonic and benthic organisms (Ferriz, 1987). Fish were caught in gill nets, and specimens placed on ice for transport to the laboratory. Fifteen fish were examined each month between January 1991 and February 1992 (Table 1), except in the closed season from September to November. Standard length, total weight, sex, gonadal weight, and presence of mesenteric fat were recorded for each specimen. Fish were examined externally and internally to detect signs of starvation such as thin backs, and vertebral deformities. Gut fullness was measured using a four grades (0, 0.25, 0.5, 1) from completely empty (0) to completely full (1). The brain was dissected, examined under a stereoscopic microscope, and the number of metacercariae of each species recorded.

Calculations of condition factor (body weight/total length³), gonadosomatic index (gonadal weight/total weight) were done. Preva-

lence, mean intensity, mean abundance were used as defined by Bush et al. (1997). Mann-Whitney and Kruskal-Wallis tests were performed to compare the abundance between sexes and between samples respectively (Conover, 1980). To detect interactions between parasites species, a Spearman rank correlation test was used for the complete data set. This test was also used to analyze the relation between abundance of both diplostomid species and host body condition, gut fullness and gonadosomatic index for each sample (Conover, 1980). Tests were set at a confidence level of 95%.

RESULTS

A total of 135 silversides (54 females and 81 males) was studied. The mean total length of fish was 27.9±2.1 cm (range 24–34) and mean total weight was 198.4±3.9 g (range 128–327). The date of each sample, number of fish, and prevalence of *T. destructor* and *D. mordax* are summarized in Table 1.

Prevalence of *T. destructor* was 100% and abundance varied between 10 and 322 larvae. Abundance of this species was significantly different between months ($\chi^2=48.1$, df=8; $P<0.05$). Mean intensity ranged from 35 (June 1991) to 140 (January 1992) (Fig. 1). This parameter varied according to fluctuations of water temperature, with higher intensities in spring and summer. Recruitment period for *T. destructor* was during spring.

Prevalence of *D. mordax* varied between 7% (January 1991) and 100% (June

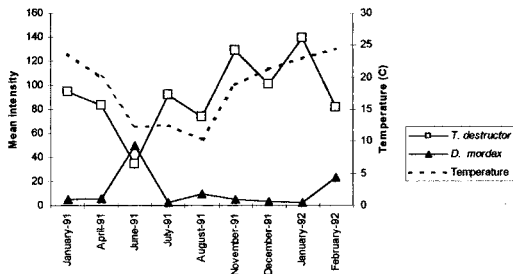


FIGURE 1. Mean intensity of *Tylodelphys destructor* and *Diplostomum mordax* in Patagonian silversides from Lake Pellegrini.

1991). Abundance of this species ranged from 0–156 larvae, and was significantly different between months ($\chi^2=85.1$, $P<0.05$). Mean intensity ranged from two (July 1991) to 49 (June 1991) (Fig. 1), and did not follow seasonal fluctuations of water temperature, showing highest mean intensity in autumn, when recruitment occurs.

All male and female silversides were infected with *T. destructor* and 66% of females and 51.8% of males had *D. mordax* in the brain. There was no significant difference in abundance between sexes for *T. destructor* ($U=1,898$, $P>0.05$) nor for *D. mordax* ($U=1,837$, $P>0.05$).

A progressive rise in mean intensity of *T. destructor* in relation to standard fish length was observed (Fig. 2) and there was a significantly positive correlation between these variables ($r_s=0.34$, $P<0.05$). Mean intensity of *D. mordax* decreased in fish over 29 cm of standard length (Fig. 2), but the variables did not show covariation ($r_s=-0.19$, $P>0.05$).

Fifty-eight percent of the fish were concurrently infected by *T. destructor* and *D. mordax*; the remainder were infected only by *T. destructor*. There was significant negative correlation between the abundance of *T. destructor* and that of *D. mordax* ($r_s = -0.47$, $P = 0.05$). Moreover, high levels of abundance of one species did not occur simultaneously with high levels of the other when infrapopulations were analyzed. Whenever abundance of *T. destructor* was

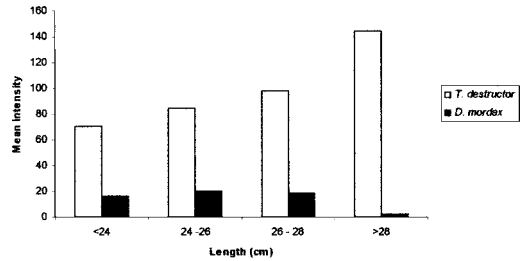


FIGURE 2. Mean intensity of *Tylodelphys destructor* and *Diplostomum mordax* in relation to length of Patagonian silversides from Lake Pellegrini.

over 50, abundance of *D. mordax* decreased (Fig. 3).

All fish examined appeared healthy, with rounded back and sides and without vertebral deformities. Ninety-seven percent of fish had mesenteric fat. Only 16.3% of the specimens had empty guts. There was no significant difference in larval intensity between fish with food in the intestine and those without food ($U=858$, $P>0.05$). There was no covariation detected in any sample between larval abundance and gut fullness, body condition factor or gonadosomatic index.

DISCUSSION

According to Szidat and Nani (1951) starvation of Patagonian silversides from Lake Pellegrini was due to high numbers (200–300) of diplostomid larvae in brain. Fuster de Plaza and Boschi (1957) found silversides with five to 100 metacercariae of *D. mordax*, and reported one specimen with 1,800 larvae; they associated vertebral

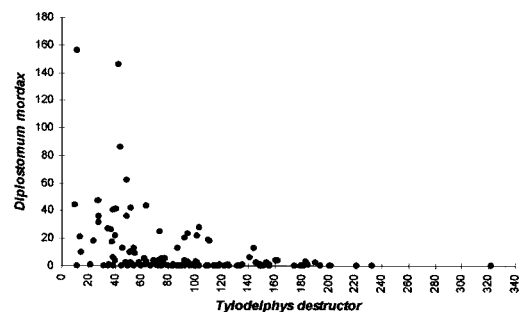


FIGURE 3. Abundance of metacercariae of *Tylo-delphys destructor* and *Diplostomum mordax* in *Patagonian silversides* from Lake Pellegrini.

deformities with diplostomid infection. In the present study, lack of association between larval abundance and condition factor, gut fullness, and gonadosomatic index suggest that diplostomid larvae in the brain do not alter feeding and growth. These observations agree with those involving Chilean silversides (Torres et al., 1996; Siegmund et al., 1997) where no deformed nor starved fish were observed, although extremely high intensities (1,800) of diplostomids such as those reported for silversides in Argentinean reservoirs (Fuster de Plaza and Boschi, 1957) were not detected.

Prevalence of *Diplostomum mordax* was maximum during autumn and decreased in winter; all examined fish were infected with *T. destructor*. Mean intensity of *D. mordax* increased in autumn and during other seasons intensity was low. *Tylodelphys destructor* had an inverted pattern of mean intensity variation, with minimum values in autumn. This species had highest intensities in larger fish, a pattern that was not observed for *D. mordax*. Torres et al. (1996) observed an infection pattern with no seasonal variation for both diplostomid species in brain of Chilean silversides from Lake Riñihue. In Lake Pellegrini the pattern of infection of *T. destructor* resembled those of *D. gasterostei* in perch (*Perca fluviatilis*) with increased mean intensity in spring and declines in winter (Kennedy and Burrough, 1977). Like *T. clavata* in perch (Kennedy, 2001), mean intensities of *T. destructor* in silversides increased in older fish, while mean intensities of *D. mordax* had a similar pattern as *T. podicipina* (Kennedy, 2001) which decreased with host age.

Cercariae of these diplostomid species probably have different optimal temperature of cercariae emergence. Ostrowski de Nuñez (1977) recorded maximum shedding of cercariae of *D. mordax* between 17–18 C. The recruitment period of *D. mordax* occurs when water temperature decreases from 20 to 12 C, which includes the optimal temperatures for cercariae

shedding. Higher temperature of cercariae emergence of *T. destructor* could be inferred from the periods of maximum mean intensity, suggesting different recruitment periods for each species.

Both species co-occur within the brain, and the abundance data show negative covariation. This produces a negative interspecific interaction pattern (Dobson, 1985). Consequently, space and food competition could be mechanisms that prevent high numbers of both species simultaneously (Kennedy and Burrough, 1977; Burrough, 1978; Kennedy, 2001). However, the observed temporal segregation of infection and the differential distribution of parasites in the host populations, suggests the absence of current competition in the brain of silversides. As Holmes (1973) described, selective segregation could be occurring. In this potential competitor system, interaction could be avoided through temporal segregation of emerging cercariae and different recruitment periods as well as preference of different age classes of the same host species. Selective segregation may have occurred within an evolutionary context, producing genetic changes in the formerly competing species, thus the resource requirement of the competitors diverged (Holmes, 1973; Esch and Fernández, 1993).

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